BBC RD 1973/35

BBC

1969
THE QUEEN'S AWARD
TO INDUSTRY

RESEARCH DEPARTMENT

REPORT

Visibility of chrominance/luminance delay inequality in System I (625-line PAL) video signals

V.G. Devereux, M.A.
G.C. Wilkinson

Research Department, Engineering Division
THE BRITISH BROADCASTING CORPORATION November 1973

BBC RD 1973/35
UDC 621.397.132

VISIBILITY OF CHROMINANCE/LUMINANCE DELAY INEQUALITY IN SYSTEM I (625-LINE PAL) VIDEO SIGNALS

V.G. Devereux, M.A.
G.C. Wilkinson

Summary

An investigation, including subjective tests, has been carried out concerning the visibility of chrominance/luminance delay inequalities in System I (625-line PAL) video signals. The results obtained indicate that the threshold of visibility of this type of picture impairment corresponds to a delay inequality of about ±50 ns on critical pictures if it results from timing errors in a video circuit handling separate chrominance (R-Y and B-Y) and luminance (Y) signals; if, however, the delay inequality is caused by group delay distortion in a circuit handling coded PAL signals, the threshold occurs at about ±100 ns.

issued under the authority of

P. Rainger

Head of Research Department

Research Department, Engineering Division,
BRITISH BROADCASTING CORPORATION

November 1973

(EL-82)

VISIBILITY OF CHROMINANCE/LUMINANCE DELAY INEQUALITY IN SYSTEM I (625-LINE PAL) VIDEO SIGNALS

Section	Title	Page
	Summary	Title Page
1.	**Introduction**	1
	1.1. Types of delay inequality	1
	1.2. Review of previously published work	1
2.	**Subjective tests**	1
	2.1. Equipment	1
	2.2. Test procedures	2
	2.3. Grading	3
	2.4. Tests for threshold of perceptibility of impairment	3
	2.5. Grading tests	3
	2.6. Discussion of results	3
3.	**Conclusions**	4
4.	**References**	4

VISIBILITY OF CHROMINANCE/LUMINANCE DELAY INEQUALITY IN SYSTEM I (625-LINE PAL) VIDEO SIGNALS

V.G. Devereux, M.A.
G.C. Wilkinson

1. Introduction

The object of the work described in this report was to obtain information concerning the impairment caused by chrominance/luminance delay inequality in System I (PAL, 625-line, 50 fields/sec) video signals using both normal pictures and critical pictures such as those having saturated colour captions. The assessment of this particular picture impairment does not appear to have been specifically evaluated for Television System I although similar work has been carried out for NTSC 525-line 60 fields/sec video signals by Lessman[1], and by Allnatt[2] on a 625-line, 50 fields/sec, NTSC video signal in terms of a picture quality rather than an impairment scale. It is to be expected that the impairment caused by a given chrominance/luminance delay inequality will be very similar for both 525-line, 60 fields/sec and 625-line, 50 fields/sec video systems as the period of one line is very nearly the same for both systems, being 63·5 μs and 64 μs respectively.

1.1 Types of delay inequality

Chrominance/luminance timing errors may be caused in two different ways.

(a) The timing of the luminance, Y, signal can be varied with respect to the baseband chrominance signals, R-Y and B-Y, either prior to coding into the composite PAL signal or after decoding from the composite PAL signal.

(b) Group delay distortion in a circuit handling coded PAL signals can alter the timing of the chrominance components at 4·43 MHz with respect to lower frequency luminance components, giving a similar though not identical effect to that resulting from cause (a).

Lessman[1] investigated both causes of delay inequality and found that for a given delay inequality, cause (a) gave the more noticeable impairment.

As mentioned below in Section 1.2(a), the delay inequalities occurring in practice are mostly due to cause (b). However, for the investigation described in this report, the relative timing of the separate luminance and chrominance components was varied because it gave more critical results and also because it provided a simple means of examining the effects of either retarding or advancing the timing of the chrominance component with respect to the luminance component. One of the advantages of examining both positive and negative delay inequalities was that it overcame the difficult problem of determining, initially, the correct adjustment of timing corresponding to zero delay inequality.

1.2 Review of previously published work

The list of published material which follows, while not claiming to be comprehensive, does give some idea of the variations encountered in the specification of chrominance/luminance timing.

(a) The 'Specification of television standards for 625-line System I transmissions'[3] published jointly by the BBC and ITA (now IBA) does not specify the maximum allowable chrominance/luminance delay inequality although it gives in Appendix IV a table listing estimates of the maximum delay inequalities to be expected at various points in the television distribution chain; these inequalities vary from ±5 ns at the output of the coder to ±109 ns at the end of a reference link. It may be noted that only ±5 ns at the output of the coder could result from cause (a) in Section 1.1, the remaining errors being due to cause (b).

(b) The CMTT* Recommendation 451-1 (CCIR Vol. V, Pt. 2, New Delhi 1970) gives a limit of ±100 ns for the delay inequality on a hypothetical reference circuit.

(c) Allnatt[2] using a 625-line, 50 fields/sec, NTSC colour system gives a figure of ±168 ns as the transition point between obtaining 'good' and 'excellent' picture quality. The method of introducing delay inequality in these tests was equivalent to cause (a) in Section 1.1.

(d) King and Brown[4] in their report 'Television System I: a proposed specification for group delay at high video frequencies' carried out all their measurements above colour subcarrier frequency and used the CMTT recommendation of ±100 ns for the specification at subcarrier frequency.

(e) Lessman[1] in his paper presented to the SMPTE in April 1971 gives a figure of 74 ns as the delay error resulting from cause (a) at which 50% of observers considered the impairment to be not worse than just perceptible on his most critical picture.

2. Subjective tests

2.1 Equipment

A block diagram of the test equipment is shown in Fig. 1.

---

*The CMTT is a joint CCIR/CCITT Study Group concerned with the point-to-point transmission of broadcast programme signals.

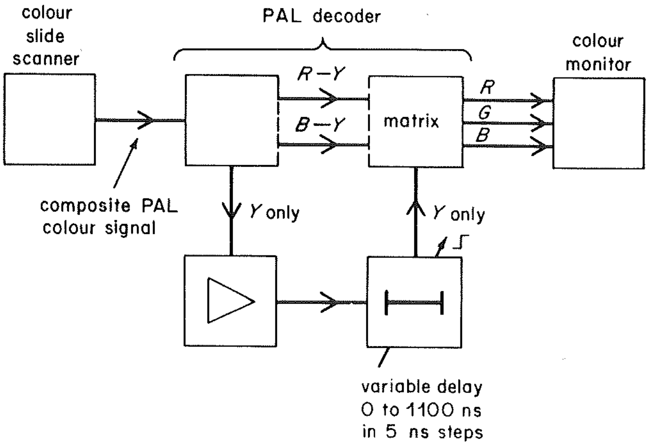


Fig. 1 - Block diagram of equipment used in subjective tests.

In order to vary the timing of the luminance signal, Y, relative to that of the chrominance signals, R-Y and B-Y, the fixed 350 ns luminance delay in a PAL decoder was replaced by a variable delay; this could be adjusted over the range zero to 1100 ns in steps of 5 ns.

The picture was displayed on a high-quality 56 cm monitor having a peak brightness of 70 candela/m^2; with zero beam current the brightness of the monitor resulting from ambient illumination was 0·1 candela/m^2.

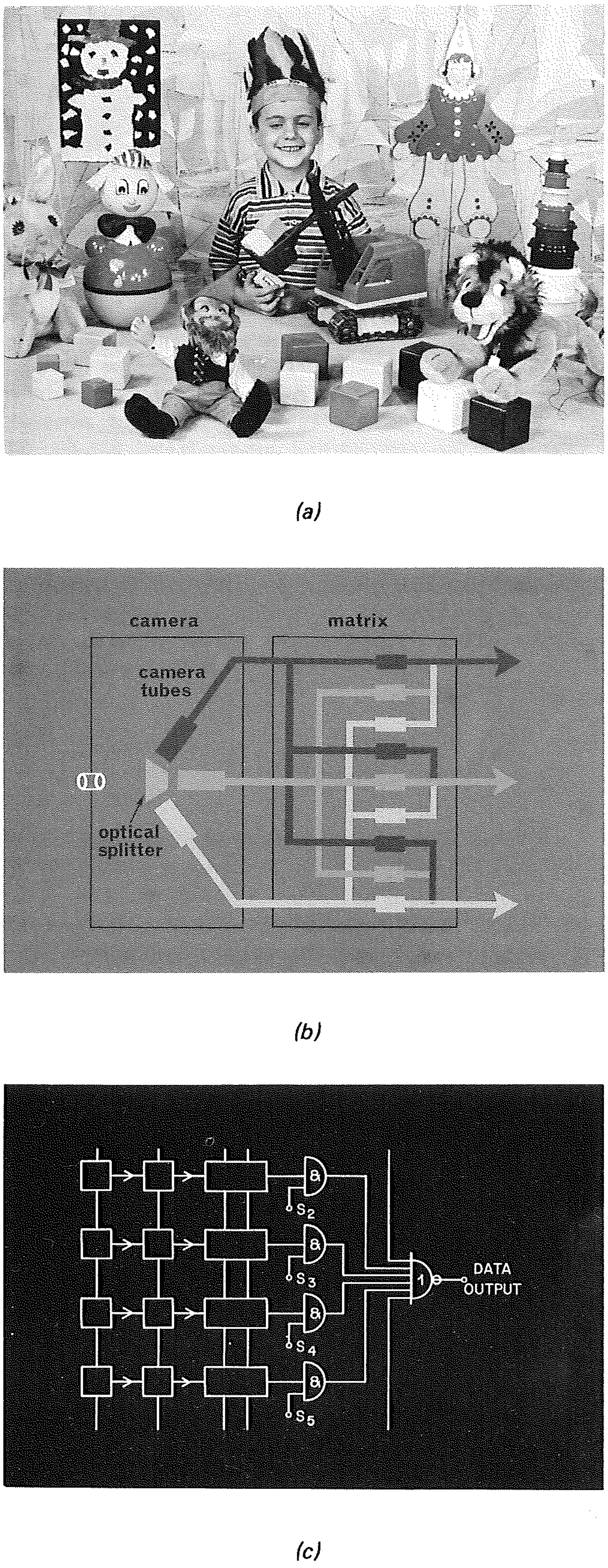
Three slides were used for the tests, monochrome versions of these being shown in Fig. 2. The 'Boy with toys' and 'Camera channel' slides were chosen because they had been used by King and Brown for their investigation. 'Camera channel' was originally selected as a critical picture for showing the effects of chrominance/luminance mistiming as it contained sharply defined red, green and blue colour areas on an orange background and many transitions between these colours.

'Block schematic' is a monochrome slide but was used to provide red, green and blue pictures on a black background by removing two of the R, G and B inputs to the PAL coder in the slide scanner. The resulting pictures were equivalent to saturated colour captions with regard to showing the effects of chrominance/luminance mistiming.

2.2 Test procedures

Ten observers were used, mostly skilled judges of television pictures and their impairment. They were seated, one at a time, at about five times picture height from the monitor.

Prior to the main tests it was found that the PAL decoder introduced different delays into the R-Y and chrominance/luminance delay inequalities being investigated. However, after certain circuit modifications, a short series of subjective tests showed that the remaining delay inequality had been reduced to about 20% of the value which



(a)

(b)

(c)

Fig. 2 - Monochrome versions of slides used in subjective tests

(a) 'Boy with toys' (b) 'Camera channel' (c) 'Block schematic'

caused a just perceptible impairment, and this was considered to be insignificant.

2.3 Grading

The 6-grade impairment scale given below was used for all the tests.

Impairment Grade

1	Not perceptible
2	Just perceptible
3	Definitely perceptible but not disturbing
4	Somewhat objectionable
5	Definitely objectionable
6	Unusable

2.4 Tests for threshold of perceptibility of impairment

In the first test the 'Block Schematic' slide was displayed in 3 different forms. Firstly, the green and blue channels of the colour scanner were disconnected and the red channel only used; additionally the signal was crushed to black and limited to peak red in the scanner so that 100% saturated colours were obtained.

On the monitor, the brightness control was adjusted so that the video level of the 'black' background was above the cut-off voltage of the cathode ray tube by an amount equal to about 10% of the difference between black and white levels: this gave a dark grey background and made the visibility of colour spreading on to the background more visible than with the correct brightness setting, and thus made mistiming more obvious. Similar tests were carried out with the green and blue channels respectively.

Each observer was asked to adjust the delay of the luminance channel so that picture impairment was judged to be on the threshold between grades 1 and 2, i.e. a nominal grade 1·5, for luminance timing both retarded and advanced with respect to the chrominance. The results obtained are given in Table 1.

The same procedure was followed with the observers in two more tests using the 'Camera channel' and 'Boy with toys' slides coded normally by the colour scanner. The results obtained are also given in Table 1.

Table 1

Slide		**Delay inequality for grade 1·5 ns**
	RED only	±65
'Block Schematic'	GREEN only	±80
	BLUE only	±77
'Camera channel'		±72
'Boy with toys'		±86

These results indicate that the 'Camera channel' picture was about as sensitive to chrominance/luminance delay inequality as the 'Block schematic' pictures while the 'Boy with toys' was slightly more tolerant.

2.5 Grading tests

In these tests, the observers were asked to judge the impairment grade for various amounts of chrominance/luminance mistiming. The 'Block Schematic' slide was not used because the tests described in Section 2.4 had shown that, for the impairment grades of most interest, it gave results similar to those for the 'Camera channel' side.

The results, given in Fig. 3, show that with the 'Camera channel' picture, grade 1·5 was reached with a delay inequality of ±40 ns; the corresponding figure for the 'Boy with toys' picture was ±50 ns.

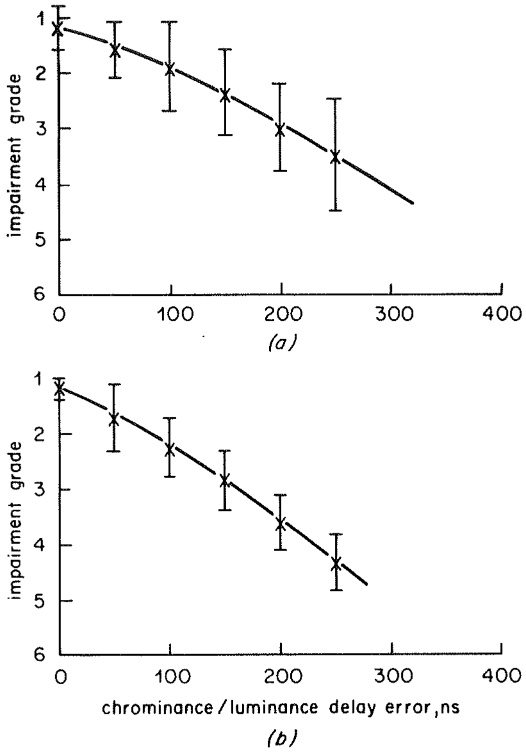


Fig. 3 - Results of grading tests
X *indicates mean grade for given delay inequality*
I *indicates standard deviation of results*
(a) 'Boy with toys' *(b) 'Camera channel'*

2.6 Discussion of results

The grading tests indicate that the results given in Section 2.4 correspond to a grade of about 1·8 rather than 1·5. However, it will be noticed that even for nominally correct timing the mean grade given by the grading tests was that 1·2, indicating that slightly pessimistic results were obtained by the grading tests when only a small impairment was present. A realistic figure for grade 1·5 with the most critical picture is therefore probably about ±50 ns.

In order to facilitate comparison of results with those obtained by Lessman, the information obtained from the

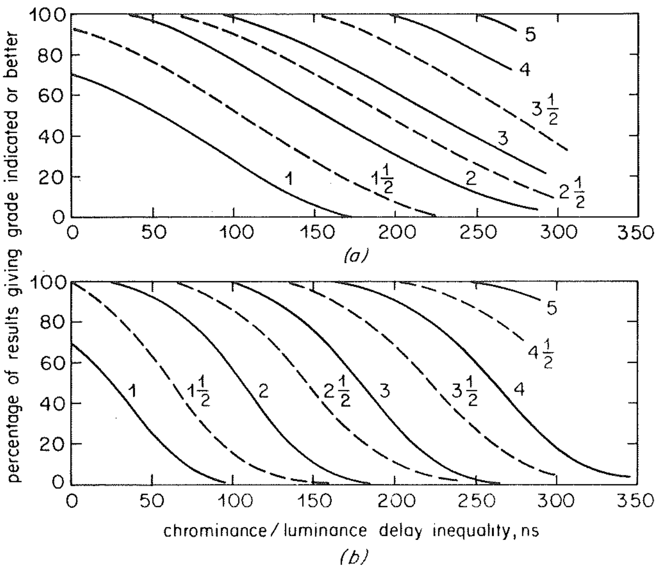


Fig. 4 - Observer opinion distributions
(a) 'Boy with toys' (b) 'Camera channel'

tests described in Section 2.5 have been re-arranged in Fig. 4 in the form of 'Observer Opinion Distributions'.

These curves show that using the 'Camera channel' slide, the results obtained were very similar to those obtained by Lessman for delay inequalities introduced into the luminance component only of 525-line NTSC video signal. (Cause (a) in Section 1.1). For example, Fig. 4(b) indicates that 50% of observers thought that Grade 2 or smaller impairment was given by a delay inequality of 107 ns while the corresponding figure given by Lessman was very close to 100 ns. However, in tests in which group delay errors were introduced into the coded NTSC signal, Lessman found that the differential delay in this case corresponding to a given subjective impairment was about twice that for mistiming of the chrominance relative to the full luminance signal in separate channels. On this basis, it would appear that the delay inequality corresponding to grade 1·5 impairment on the most critical pictures as a result of group delay errors in a PAL, 625-line video signal is about ±100 ns.

One of the purposes of the work described in this report was to extend the work by King and Brown on the effect of group-delay errors in a coded PAL video signal down to colour subcarrier frequency. In the King and Brown tests, the group-delay error at subcarrier frequency was deliberately adjusted to be very small, as the purpose of the tests was to examine the effect of group-delay errors above this frequency. Their curve indicating group-delay errors corresponding to grade 1·5 was tailored into the figure at subcarrier frequency recommended by the CMTT, i.e. ±100 ns (see Section 1·2(b)). From the discussions given above this value appears to be entirely suitable for that purpose, i.e. for group-delay errors in a composite PAL signal initially of high quality.

3. Conclusions

A basis for specifying chrominance/luminance delay inequality in a System I (625-line PAL) video signal has been provided by a series of subjective tests.

The tests indicate that for the most critical types of picture, the impairment caused by chrominance/luminance delay inequality will be within acceptable limits for broadcast quality pictures if the inequality is no greater than ±50 ns. It should be noted that this figure was obtained by introducing a timing error into the luminance path of a colour signal split up into its separate luminance (Y) and colour-difference (R-Y and B-Y) components.

Work carried out by Lessman[1] indicates that where chrominance/luminance delay inequalities are introduced by group delay errors in a channel handling a composite colour signal, the acceptable limit could be relaxed to about ±100 ns. It should not be forgotten that the impairments arising from the two causes of delay inequality may add directly in a complete television chain.

4. References

1. LESSMAN, A.M. 1971. Subjective effects of delay difference between Luminance and Chrominance information of the NTSC television signal. *J.Soc. Motion Pict. Telev. Engrs.*, **80**, 8, pp. 620–624.

2. ALLNATT, J.W. 1965. Subjective quality of colour-television pictures impaired by gain and delay inequalities between the luminance and chrominance channels. *Proc. Instn, elect. Engrs.*, 1965, **10**, pp. 1819–1824.

3. Specification of Television Standards for 625-line System I Transmissions, London, BBC/ITA, 1971.

4. KING, R.W. *and* BROWN, A. 1972. Television System I: A proposed specification for group delay at high video frequencies. BBC Research Department Report No. 1972/39.

CLA/JUC
(EL-82)

Printed by BBC Research Department, Kingswood Warren, Tadworth, Surrey